Rhodora

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LITHOLOGICAL FACTORS LIMITING THE RANGES OF PINUS BANKSIANA AND THUJA OCCIDENTALIS.

M. L. Fernald.

In the *Botanical Gazette* for December, 1918, Professor A. H. Hutchinson[1] discusses at length the factors which limit the northern ranges of various species of forest trees and presents maps and charts which at first glance may appear authoritative. When, however, one sufficiently examines the details to see that on the first map *Abies canadensis* (no. 9) is indicated as having a northern limit in Newfoundland, central Labrador and southern Keewatin, while *Picea canadensis* (no. 2) extends to northern Labrador, Ungava Bay, and the northwest side of Hudson Bay, he at once sees that this paper belongs in the same class as many other so-called phytogeographic and ecological articles which appear in our American journals. *Abies canadensis* and *Picea canadensis* are identical! The White Spruce was called by Miller (1768) *Abies canadensis* and by Link (1841) *Picea alba*, but on account of the earlier specific name of Miller's is now known as *Picea canadensis*. In 1803, to be sure, the name *Abies canadensis* was used by Michaux for the Hemlock, which since 1855 has been separated as a member of the genus *Tsuga*, but Hutchinson gives *Tsuga canadensis* a separate range, to the south of *Abies canadensis*. If he is using the name *Abies canadensis* in a novel sense it is unfortu-

[1] Hutchinson, Bot. Gaz. lxvi. 465–493 (1918).

nate that no explanation is given of the exact identity of the tree intended.

Hutchinson has drawn his statements of ranges chiefly from a few authors, Bell, Macoun, and Low, and states that "the records of the explorers mentioned have been even more accurate than has generally been conceded." Certainly these records are a good basis but, like other records, they cannot be safely copied without careful sifting; and, although Bell's personal observations seem to be accurate, his generalizations and deductions from others are woefully inaccurate. Thus, Bell's statement that the American Elm occurs in Newfoundland goes back to old records of superficial and self-confident English travellers who wrote with a disregard of precise taxonomy which could commend their publications only to that group of American "phytogeographers" who abhor both taxonomic accuracy and the painstaking and unending study necessary for its achievement. The Elm has been included in various journals of travel in Newfoundland through a system of "back-door" determinations but in this case, as in most others, the identification of the species merely by looking up the local name in the index of a manual has led to confusion. The situation is as follows: in Newfoundland Yellow Birch, *Betula lutea*, is known as WITCH HAZEL while in England the latter name has been used for *Ulmus montana*. Therefore, what more natural than for Sir Richard Bonnycastle, writing of Newfoundland trees from a "first-hand unfamiliarity" with them, to refer to "ulmus montana, the wych hazel, or elm, which . . . grows all over the island"? Bonnycastle's record was forthwith seized upon as proof that *Ulmus americana* grows in Newfoundland, although others, relying merely on indices of American manuals, have treated it as *Hamamelis virginiana*. Neither *Ulmus* nor *Hamamelis* is known in Newfoundland!

By too closely following the now almost ancient paper of Bell[1] and quite disregarding the scores of very accurate and detailed accounts by later Canadian explorers, Hutchinson has slipped into some errors which a few hours of intelligent search of literature would have prevented. Thus he states (p. 476) that "the irregularity of the limits of *Pinus Banksiana* may be explained by the fact that although temperature conditions have so changed that this species has migrated to 56° N. lat. in the highlands of northern Quebec, it has

[1] Robert Bell, Geol. Surv. Can. Rep. for 1879–80, 44–56C (1881).

been limited in its northward progress by the low lying lands south and westward from James Bay," quite overlooking the fact that W. J. Wilson of the Geological Survey of Canada found and recorded[1] *P. Banksiana* in the valley of the Kapiskau River which flows through "the low lying lands . . . westward from James Bay," 160 miles north of Hutchinson's northern limit in that longitude.

On the other hand, by *not* closely following the trustworthy records of that wonderful authority on the Labrador Peninsula, A. P. Low, he has unfortunately abbreviated the northeastern limits of many species: *Betula papyrifera* by 160 miles and *Picea mariana* (*nigra*) and *Larix* each by 75 miles; while failure to get at other sources of information has materially shortened others of Hutchinson's limits: thus *Populus balsamifera,* as shown by the representation in the Gray Herbarium, reaches Hebron in latitude 58°, on the outer coast of Labrador, 185 miles beyond Hutchinson's northeastern limit. In fact, from Hutchinson's map one would infer that north of Hamilton Inlet the whole Atlantic slope of Labrador is treeless, but of course this is not the case. Witness the statement of Low who intimately knew Labrador: "The tree-line" after skirting Ungava Bay turns southeast, then "southward to the neighbourhood of Hebron, in latitude 58°, where trees are again found in protected valleys at the heads of the inner bays of the coast. At Davis Inlet, in latitude 56°, trees grow on the coast and high up on the hills, the barren grounds being confined to the islands and headlands. . . . These barren islands and bare headlands of the outer coast . . . have caused a false impression to be held regarding much of the Atlantic Coast."[2] With this definite statement and warning by Low, whom Hutchinson says he is following, it is unfortunate that he should have perpetuated the false impression that Atlantic Labrador is treeless.

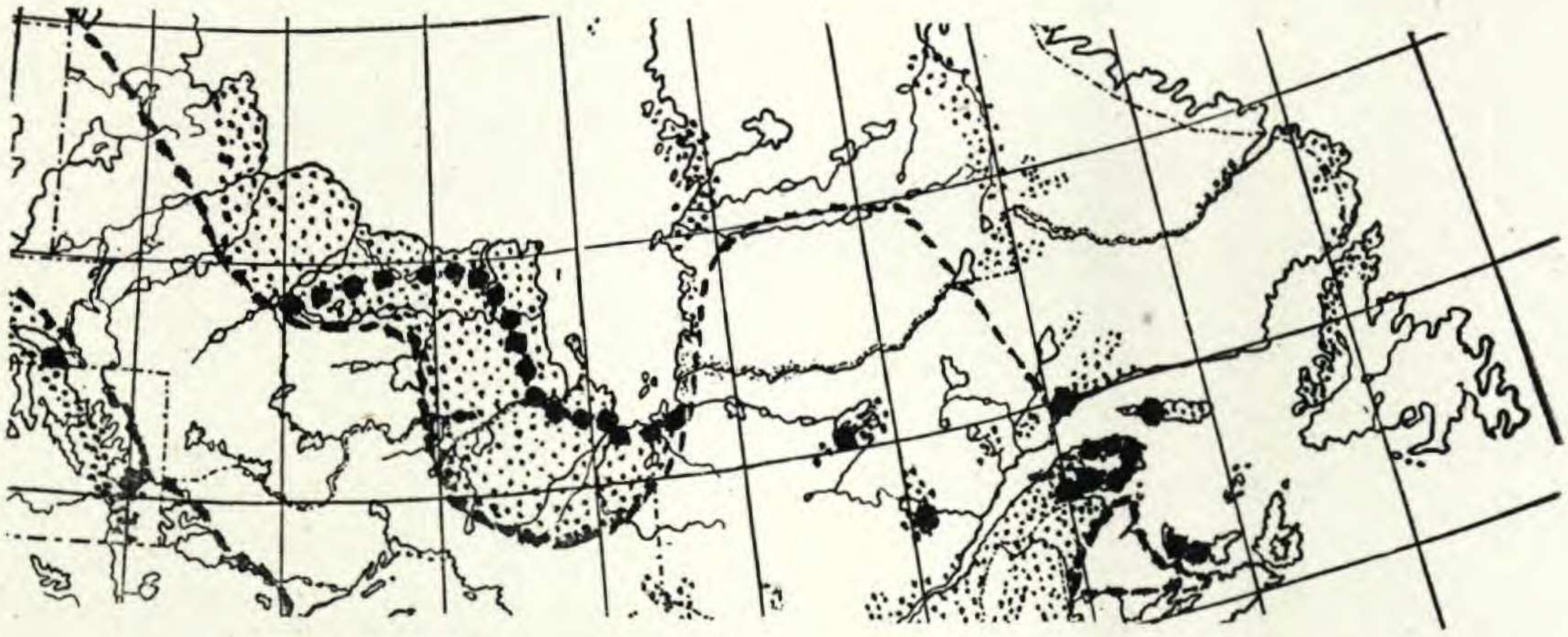
But, although for the sake of precision it is important to call attention to these inaccuracies in compilation which at once alter the premises, the chief object of the present notes is to emphasize one dominant factor in determining the limits of ranges of plants, the neglect of which has so obviously led Hutchinson into confusion. Repeatedly in his paper he refers to what are described as the "anomalous" distribution of *Thuja occidentalis* and the "irregularities" and "inconsistencies" in the distribution of *Pinus Banksiana;* and

[1] Geol. Surv. Can. Ann. Rep. n. s. xv. 226A (1903).
[2] A. P. Low, Geol. Surv. Can. Ann. Rep. n. s. viii. 31L (1896).

although the same perfectly elementary law of phytogeography could as well be brought out by contrasting the detailed ranges of many other species, such as *Picea mariana* and *P. canadensis*, *Casianea dentata* and *Juglans cinerea*, *Quercus Prinus* and *Q. Muhlenbergii*, we may appropriately take for this examination the "anomalous" and "irregular" or "inconsistent" ranges emphasized by Hutchinson.

Briefly, the "anomalies" or "irregularities" consist in the facts that, although the White Cedar, *Thuja occidentalis*, is "unusually large and fine in New Brunswick and the Gaspé peninsula," it is unknown in Newfoundland, Cape Breton, and Nova Scotia where, we are told, "the climate, soil, etc., are the same"; and that, although Banksian Pine "extends northward to 56° N. lat. on the dry uplands east of Hudson Bay," it is "practically eliminated from the low lying lands to the south and west of Hudson Bay and James Bay, water [so Hutchinson says] being the limiting factor." It is further stated that the "anomalous" distribution of *Thuja occidentalis* "defies explanation by regarding temperature, water, or soil as the limiting factors" and, furthermore, that "Cowles has shown that the composition of the rock from which any soil may be derived seldom acts in a limiting capacity with respect to the species which that soil may support. It is only in exceptional cases that a soil newly weathered, is deficient in the mineral constituents necessary for plant growth. This generalization is particularly applicable in Ontario, where the soil, whether it be glacial drift toward the south or the weathered deposits and exposed rocks farther north, is derived from the dominantly granitic rock of the Laurentian Plateau. The original composition of the soil is seldom a limiting factor, at least in so far as the forests of Ontario are concerned."

When we carefully study, however, the detailed ranges of these two species and take pains to discover the lithological character of each region where the species truly prospers and of all their outlying or extra-limital stations we shall find that, far from "defying explanation," the broad ranges and especially the outlying stations are readily explained by the chemical character of the soil, whether acid or basic. Pinus Banksiana *is confined to acid soils;* Thuja occidentalis *chiefly to basic soils and it reaches its maximum development and all its outlying stations only in positively calcareous areas.* The evidence upon which these generalizations are made is stated below.



Northern limits of *Pinus Banksiana* (broken lines) and of *Thuja occidentalis* (heavy spots): calcareous regions dotted.

Pinus Banksiana.

As Hutchinson states, on the Labrador Peninsula the Banksian Pine "extends northward to 56° N. lat. on the dry uplands east of Hudson Bay." This statement is supported by Low, from whom it was derived, and Low states with positiveness that "The soil of the greater part of the peninsula is derived from the underlying Archaean rocks," i. e. the acid granite-gneiss (Low, n. s. viii. 30L). West of the Labrador Peninsula the rocks on which the Banksian Pine grows are likewise invariably acid or neutral. The detailed accounts of the scores of areas described in the Annual Reports of the Geological Survey of Canada are replete with this evidence and a few brief but characteristic quotations are here included from the almost endless series of notes to the same effect, the name of the recorder and the number and page of the report being indicated in parentheses.

On the Noddoway River, emptying into Rupert Bay, an arm of James Bay, "Banksian pine is found, where suitable conditions exist, as far as Mattagami Lake, but its range towards James Bay is not restricted on account of the latitude, but by some other circumstance, for in a slightly more easterly longitude this tree ranges northward to Great Whale River, a distance of about 450 miles in a straight line from Mattagami Lake" (Robert Bell, n. s. viii. 79A). In the region southeast of Mattagami Lake "a considerable proportion of the area . . . consists of granitic rocks," but "from the above-mentioned point

(about six miles northward of the narrows or outlet of Mattagami Lake), gneisses with some granitoid patches and occasional bands of micaceous and hornblende schists were the only rocks met with *in situ* all the way to Rupert's House." "The rocks consist principally of a variety of schists, such as dioritic, chloritic, hornblendic, and micaceous and also slatey arkose, alternating with massive greenstones" (Bell, l. c. 83, 84A). In other words, *Pinus Banksiana* stops in its northwestern range along the Noddoway as soon as it reaches the region of dioritic and hornblendic schists and greenstones, i. e. the calcareous region. Furthermore the drift of the region, derived from the shores of James Bay, contains a "certain proportion from the Manitounuck and Devonian rocks of James Bay, the percentage of these latter increasing as we went northward. Beyond Mattagami Lake this percentage became very considerable" (Bell, l. c.). The Manitounuck of James Bay is described as "made up mostly of limestones . . . sandstones and quartzites, shales, ironstones, amygdaloids and basalts" (Bell, Rep. for 1877–8, 11, 12C) while the Devonian rocks of James Bay consist "of dark grey bituminous limestone, interstratified towards the bottom with earthy drab limestone" (Bell, Rep. for 1875–76, 316). The drift material from Mattagami Lake northward, where the percentage of Manitounuck and Devonian fragments becomes "very considerable" is, therefore, also calcareous, and it is more than a mere coincidence that at this point the range of *Pinus Banksiana* along the Noddoway should abruptly end.

In the Nipissing and Temiscaming region "Jack-pine, called by some pitch-pine, or bastard spruce (*Pinus Banksiana*) is very often encountered in the more barren and rocky areas, and its presence seems an almost certain indication of the extreme poverty of the underlying soil" (Barlow, n. s. x. 34I). Somewhat farther west, in the area northeast of Lake Nipigon, "The height of land region . . . though level and swampy, is mostly of a sandy nature," "The timber in the height of land region is small spruce and tamarack with Banksian pine on the sand plains and higher land" (W. A. Parks, n. s. xv. 220A). Still farther west in Ontario, in the region west of Thunder Bay, "The greater part is occupied by Archaean rocks" (McInnes, n. s. x. 6H), and *Pinus Banksiana* is reported to be the most abundant tree of the region (McInnes, l. c. 11H).

Farther northwest, in Keewatin, in the valley of the Kanuchuan, "Everywhere, excepting on the muskeg areas, there is an open forest

of banksian pine" and the country which is a "sandy flat, gradually rises southward for five or six miles, then it sharply rises to a ridge of gravel and boulders [gneiss]" (McInnes, n. s. xvi. 155A). Similarly in other regions of the upper Severn where "the whole area is occupied by rocks of Archaean age" (Camsell, n. s. xvi. 147A) "banksian pine and birch are found everywhere over the whole district" (Camsell, l. c. 151A); and so on through many other reports.

Hutchinson finds the range of *Pinus Banksiana* "irregular" because "It is practically eliminated from the low lying lands to the south and west of Hudson Bay and James Bay," naively adding, "water being the limiting factor." When, however, we look into the lithology of the "low lying lands to the south and west of Hudson Bay and James Bay" the remarkable *regularity* or *consistency* of the range of *Pinus Banksiana* is made apparent, for this vast region from which *Pinus Banksiana* is "eliminated" consists of Silurian and Devonian limestones. On the splendid Geological Map of North America, published in 1911 by the United States Geological Survey, this limestone region to the south and southwest of Hudson Bay is indicated as extending from Rupert Bay to the Churchill River, a distance (air line) of 850 miles, with a breadth at the southwest of more than 200 miles. Yet Hutchinson, finding the Banksian Pine "practically eliminated" from this region but abundant on acid Labrador and there extending north to latitude 56° says that "water" is "the limiting factor"; and he fails to detect the real factor because at the very outset he had somehow got an idea that "COWLES has shown that the composition of the rock from which any soil may be derived seldom acts in a limiting capacity with respect to the species which that soil may support."

And it is not merely Cowles who has thus argued, for this dogmatic assertion has been repeatedly made by other leading American ecologists. We thus find Clements writing: "Apart from the effect which excessive amounts of acids and salts may have in reducing the chresard, the chemical character of the soil is powerless to produce structural modification in the plant. Since Thurmann's researches there has been no real support of the contention that the chemical properties of the soil, not its physical nature, are the decisive factors in the distribution and adaptation of plants."[1]

[1] Clements, Research Methods in Ecology, 80 (1905).

Although *Pinus Banksiana* is, like other pronounced oxylophytes, "practically eliminated" from the vast limestone region to the south and southwest of Hudson Bay, it is important to note the adverb "practically," for where ridges of acid gravels or sands occur *Pinus Banksiana* is likely to occur with them. Thus, in ascending the Kapiskau River which flows through the limestones and calcareous clays into the west side of James Bay, W. J. Wilson (already referred to) left the river to explore an isolated ridge, which proved to be a kame "composed chiefly of gravel" (W. J. Wilson, n. s. xv. 226A) which was "covered with Banksian pine, canoe-birch and poplar."

All explorers agree that the Banksian Pine "does not touch either James' Bay or Hudson's Bay" (Bell, Rep. for 1879–80, 46C). Its essential absence from the region between the lower Noddoway and the Churchill River has already been sufficiently studied. How about the east side of James Bay? Low agrees with Bell that on the Labrador side it "does not come quite to the coast on Hudson or James Bay," adding the guess: "probably on account of the shore being generally low and swampy." Yet is it not significant that near the entrance of the East Main River into James Bay from the east, there should be bands of limestone "a few miles above its mouth, and along the coast of James Bay in the vicinity of that river" (Low, n. s. viii. 200L); that the next large river northward, the Big River, has its banks for several miles above its mouth "composed chiefly of bluish white clay" (Low, n. s. iii. 38J); and that, farther north, the lower stretches of the Great Whale River likewise flow through a "deposit of clay" which is full of "marine fossil shells" (Low, l. c. 53J)?

West and northwest of the calcareous "low lying lands to the south and west of Hudson Bay and James Bay," the region so generally avoided by *Pinus Banksiana,* occurs the great western Archaean barren region, extending from Lake Superior west to Lake Winnipeg, and north to the Arctic; and here, naturally enough, the Banksian Pine extends "north-westerly to the Athabasca River, . . . and northerly down the Mackenzie River to the arctic circle" (Macoun). The accounts of discerning explorers through this tremendous tract all emphasize the abundance of the pine on the most sterile areas: thus, throughout his extended report (n. s. viii. D) on the Athabasca Lake region, J. B. Tyrrell continually refers to the abundance of Banksian Pine on the sandy plains; and so on without seeming limit.

In fact, it is most difficult to comprehend how a phytogeographer, who must have seen a geological map of North America, can read Robert Bell's account of the broad northern range of *Pinus Banksiana* without suspecting the truth. Here is Bell's statement somewhat condensed: "from the head of the Bay of Chaleur," it extends north to Lake Mistassini, "from which it runs west to the Moose River, keeping about 100 miles south of James' Bay. . . . It does not touch either James' or Hudson's Bay. Southward it is common on the north shore of Lake Huron and around both shores of Lake Superior, whence it is met with all through the country to Lake Winnipeg." "From [the upper] Moose River it runs north-west to the Mackenzie, which it crosses about the Arctic Circle" (Bell, Rep. for 1879–80, 46C).

The southern outliers of *Pinus Banksiana*, too, are exclusively on acid and hopelessly barren rocks and sands or in acid bogs, for, although the species is commonly found on dry uplands, in the sterile southeastern area of New Brunswick it sometimes occurs on the acid bogs so that in that region at least "water" is not "the limiting factor." Although Bell has made the wholesale statement that *Pinus Banksiana* "occurs throughout Nova Scotia and New Brunswick" (Bell, Rep. for 1879–80, 46C), the Banksian Pine is, as a matter of fact, a highly localized tree in those provinces,[1] Fernow correctly stating that in Nova

[1] The loose and inaccurate generalization above referred to is an illustration of a type of statement which, when depended upon by others, at once leads to erroneous conclusions and which, most unfortunately, floods our so-called phytogeographic and ecological literature in America. Consequently those who have "a first-hand unfamiliarity" with the facts (for this apt phrase we are indebted to Dr. D. F. Jones's refreshingly straightforward review in Science for October 4, 1918) — consequently, those who are not in a position to weigh the values of statements are bound to be misled. Thus, in a recent sumptuously illustrated publication issued by the New York State College of Forestry and therefore bound to be considered "scientific," the state of New York is divided into a number of "Zones," the first the "*Zone of Willow Oak, Sweet Gum, Persimmon, etc.*" "continuing along the Connecticut coast" (to New Haven, as indicated on the accompanying map). This "Zone" which is said to occupy the western coast of Connecticut is reported by Bray to be characterized by the following

"*Indicator Species.*

Short-leaf pine	= (*Pinus echinata* Mill.).
Willow oak	= (*Quercus phellos* L.).
Oak	= (*Quercus pagodaefolia* (Ell.) Ashe).
Black-jack Oak	= (*Quercus marilandica* Muench.).
Laurel magnolia	= (*Magnolia virginiana* L.).
Sweet gum	= (*Liquidambar styraciflua* L.).
Hop tree	= (*Ptelea trifoliata* L.).
Mistletoe	= (*Phoradendron flavescens* (Pursh) Nuttall).
Virginia spiderwort	= (*Tradescantia virginiana* L.).
Day flower	= (*Commelina virginica* L.)."

Now, the disheartening features of this list of "*Indicator Species*" are that, while 6 out of the 10 are locally indigenous in southeastern New York, 3 of the others (*Ptelea*, *Tradescantia*,

Scotia "it is found only in special localities on poorest sites in Colchester county."[1] In New Brunswick, too, the tree is localized and Robert Chalmers correctly understood the situation when he wrote of eastern New Brunswick the following accurate account:

"In New Brunswick, as indeed, in all glaciated countries, however, we cannot determine the exact limits of the areas of the forest growth affected by the geological formations. On the hills and ridges underlain by limestones, we meet with maple and birch groves, intermixed occasionally with spruce. The Cambro-Silurian and the old crystalline belts of rocks traversing the province from the Baie des Chaleurs to the Chiputnecticook Lakes, seem also to mark a boundary in the forest distribution. North of this lies the great area of Silurian limestones, south of it the Carboniferous sandstones. Owing to the larger extent of country which these formations occupy, the soil necessarily bears a closer relation to the underlying rock, and is less intermixed with extra-limital drift; consequently the vegetation and forest growth upon these areas ought to show the effect of each particular kind of soil upon the flora of the country. Have these districts any peculiar forms in their floral productions?

"On the Silurian limestones there is observable a paucity of ericaceous plants, of scrub pine [*P. Banksiana*] and black spruce, and an almost entire absence of hemlock, all of which are abundant on the Carboniferous sandstones, the latter tree, indeed, reaching fuller development on these as regards size and number than elsewhere in the province. White spruce, fir, white pine, the paper birch, and

and *Commelina*) are in southeastern New York usually considered merely garden-escapes and the 10th species (*Phoradendron*) is not known north of Monmouth County, New Jersey; furthermore, of the 10 "*Indicator Species*" only 1 (*Liquidambar*) is unquestionably indigenous in Connecticut, 2 (*Ptelea* and *Tradescantia*) are garden-escapes, though *Tradescantia* may be locally indigenous, and the remaining 7 are entirely unknown in the state of Connecticut!

Again, in Hawley & Hawes's *Forestry in New England*, a book now being freely quoted, we find such an amazing statement as that "PITCH PINE (*Pinus rigida*) . . . occurs throughout New England in the extreme northern part, and in the mountains"; whereas, as a matter of fact, the Pitch Pine is a coastal plain tree extending into New England from the south. In Vermont it is found only "in the northern portion of the Champlain Valley" and "in the Connecticut Valley as far north as Wells River" (Burns & Otis); but, although the "northern portion of the Champlain Valley" suggests northern New England, it should be borne in mind that the altitude is slight, that this sandy region has to a great extent a coastal plain flora and that northernmost New England is nearly 150 miles farther north than Lake Champlain. In New Hampshire Pitch Pine follows north "along the Merrimac valley to the [bases of the] White mountains and up the Connecticut valley to the mouth of the Passumsic" (Dame & Brooks); in Maine it is confined to the southwestern sixth of the state and the coastal granites east to Mt. Desert Island. It is quite unknown among the higher mountains.

[1] Fernow, Forest Conditions of Nova Scotia, 11 (1912).

beech appear also to be more abundant upon the Carboniferous area, though common also upon the Silurian uplands. But the striking features of the forests upon the latter are the groves and ridges of birch and maple occurring in almost every part. These are seldom met with on the sandstones except where Lower Carboniferous limestones prevail.

"The comparative abundance of ericaceous plants on the Carboniferous areas is doubtless due, in some measure, to the flat surface and consequent imperfect drainage, resulting in the formation of swamps, peat bogs, etc., where these forms of vegetation find a congenial habitat. But the difference in the sylvan growth occupying the drier grounds of the two regions in question is not explicable unless we admit that the geological formation has an influence upon it. On the sandstone area, the hemlock and scrub pine are most abundant trees compared with their distribution upon the Silurian uplands. Black birch, beech, and black spruce also appear to be more common and larger. These facts regarding distribution lead to the inference that the gravelly, siliceous soil overlying the sandstones is more favourable to the growth of these trees, or it may be that the limestones are unfavourable, or, perhaps, both causes operate." (Chalmers, n. s. vii. 140, 141M).

Although on the acid north shore of the lower St. Lawrence the Banksian pine "occurs abundantly" eastward to "the neighbourhood of the mouth of the Moisie River" (Low, n. s. viii. 34L), i. e. east to longitude 66° W., and although it is on thoroughly leached and consequently acid Permian sands of Prince Edward Island in longitude 64° W. and on the "poorest sites in Colchester county," Nova Scotia, to longitude 63° W., it is noteworthy that this species should be unknown on the calcareous Gaspé Peninsula which in latitude lies midway between the "north shore" and Nova Scotia and in longitude fails to reach eastward to the 64th meridian. In his account of the limestone region of northern New Brunswick and southern Gaspé (Bonaventure County) Chalmers enumerates the trees "in the order of their relative abundance" and, although, as would be expected in a calcareous tract, *Picea canadensis* with trunks 2–2½ feet in diameter and *Thuja occidentalis* with trunks 1–3 feet in diameter head the two lists, the first for "drier parts of the Silurian upland" the other for the "lower grounds," *Pinus Banksiana* is not mentioned at all in either list (see Chalmers, n. s. ii. 33, 34M). In an intensive study of

the Gaspé Peninsula and the literature bearing upon it the present writer has found absolutely no evidence of the Banksian Pine in that vast Silurian and Cambrian region, the only known stations on the peninsula being on the leached crests of some of the intrusives at the southwest corner of the peninsula, while farther west the pine reappears on the quartzites of Rimouski County.

It is also noteworthy that along the north shore of the lower St. Lawrence, after "occurring abundantly" eastward to "the neighbourhood of the mouth of the Moisie," *Pinus Banksiana* should abruptly stop, for on the acid barren lands of northwestern Canada it extends north quite to the Arctic. Is it not significant, then, that in "the neighbourhood of the mouth of the Moisie" there should be a great mass of anorthosite 60 miles broad, and east of that another, for analyses[1] of 24 samples of anorthosite from different regions of Labrador, Canada and the Adirondacks, show it to contain an average of 9 % of calcium, the amount often reaching 18 %; and that east of these anorthosites lies the extensive limestone tract including the Mingan Islands and "the neighboring coast," for "a distance of forty-five miles," "the Mingan development of the Calciferous formation" having a thickness of 250 feet (see Logan, Geol. of Canada, 119–121)?

In Maine there is not a single known station for *Pinus Banksiana* which is not on granite or the most highly siliceous of rocks. In New Hampshire the species is only on Welch Mt., a sterile granite mass south of the syenitic Franconia Range; in Vermont it "is one of the rarest of our trees" growing on "sandy, sterile soil; rocky slopes."[2] Similarly in New York and the Great Lake States the Banksian Pine belongs to the most sterile habitats, and very recently Rosendahl & Butters have stated that in Minnesota and Wisconsin "The Jack Pine (*P. Banksiana* Lamb.) occurred most abundantly on sandy outwash plains . . . and in the great paleozoic sand plains."[3]

These facts and many scores of monotonously similar ones which the writer refrains from merely piling up are sufficient evidence that the BANKSIAN PINE *is a pronounced oxylophyte.*

In spite of the fact that *Pinus Banksiana* is essentially absent from the great limestone region bordering the southwest side of

[1] Adams, Geol. Surv. Can. Ann. Rep. N. S. viii. 1305 (1896).
[2] Burns & Otis, Trees of Vermont, 31 (1916).
[3] Rosendahl & Butters, Pl. World, xxi. 107 (1918).

Hudson Bay north to Churchill, from the calcareous Gaspé Peninsula and from Nova Scotia (with the exception of Colchester county on the isthmus which connects with New Brunswick) Transeau, discussing the ranges of forest trees, has issued a map[1] which carefully includes in the area where this species (as *P. divaricata*) is said by him to be "dominant," the 850 miles of limestones along the southwest side of Hudson Bay, and his dotted lines, which form the boundaries, embrace between their eastern terminals all of Nova Scotia, New Brunswick and Gaspé, as well as all of central and nothern Maine. The absence of *Pinus Banksiana* from the west side of Hudson Bay, from Gaspé and from Nova Scotia has been sufficiently emphasized. Similarly in the region of Maine indicated on Transeau's map the species has but few limited areas, these all on the granites and quartzites of the upper Penobscot, Kennebec, and Androscoggin; but, although "Lumbermen call it a scarce tree in Northern Maine,"[2] *south* of Transeau's boundary it is truly dominant on some of the sterile regions of the Maine coast. Transeau's map, then, which has been accepted by other ecologists as authoritative, represents *Pinus Banksiana* as "dominant" on 150,000 square miles of country from which actually the tree is essentially unknown. To the ecologist this discrepancy may seem trivial. At least, when the present writer criticized[3] the inaccuracies of Harshberger's work, where he made *Anemone narcissiflora*, which is actually unknown east of the alpine regions of Colorado, and *Cassiope tetragona*, unknown nearer than northernmost Labrador, typical forest plants of the Great Lake region, and confused *Vallisneria spiralis* of fresh water with the salt-water Eel Grass, *Zostera marina*, Cowles characterized these and the hundreds of other similar cases which crowd the pages of Harshberger's work as errors which "to taxonomic specialists of local areas . . . loom large," while "to those of broader view-point, however, the numerous errors will be subordinate."[4] If such errors are merely "subordinate," how preposterous an error, one would like to know, would be required to "loom large" in the mind of an ecologist?

[1] Transeau, Am. Nat. xxxix. 875, fig. 1 (1905).
[2] Goodale, Prelim. Report Nat. Hist. and Geol. Me. 127 (1861).
[3] Rhodora, xiii. 213–224 (1911).
[4] Cowles, Bot. Gaz. liii. 181 (1912).

Thuja occidentalis.

Hutchinson says that, "The 'anomalous' distribution of *Thuja occidentalis* defies explanation by regarding temperature, water or soil as the limiting factors: . . . 'It is absent in Newfoundland, Cape Breton, Nova Scotia, and the east half of Prince Edward Island, but unusually large and fine in New Brunswick and the Gaspé peninsula, in which the climate, soil, etc., are the same as in the adjacent regions, where no trace of the species is to be found.'" It is certainly startling to read that the climate and soil of Newfoundland, Nova Scotia, New Brunswick, Prince Edward Island, and Gaspé are so uniform, for in sections of western Nova Scotia peaches are raised with great success, but he would be a foolish man indeed who would think of planting a peach orchard in Newfoundland or in Gaspé county; and in view of the remarkably spotted and pied colorings of a geological map of this region it is further obvious that the generalization quoted above is wholly inaccurate.

Bell and following him Hutchinson are correct, however, in stating that in the Gaspé Peninsula and at least in northwestern New Brunswick *Thuja occidentalis* attains an unusual development, and had they been familiar with the region they would have extended the limits of this area of "unusually large and fine" trees into northeastern Maine. Chalmers's statement that in this Silurian limestone region the trunks of *Thuja* range from 1–3 feet in diameter has already been noted. These figures are, however, by no means the maximum, for at many points in northern Maine the writer has measured Cedars with trunks 4–6 feet in diameter. In southeastern New Brunswick *Thuja occidentalis* is localized and there chiefly a swamp shrub or dwarfed tree, obviously not in a wholly satisfactory environment. This region, the Eastern Plain of Ganong,[1] is the extensive area of Carboniferous sandstones, already referred to under *Pinus Banksiana*. To the southeast of the Carboniferous plain lie the Southeastern Highlands, in the east chiefly of granites and felsites, and at the extreme southeast lies the extensive Permian sandstone region which continues for 100 miles along the northern side of Nova Scotia. Chalmers describes this region as having some excellent farms along the coast and in the

[1] Ganong, Bull. Nat. Hist. Soc. N. B. iv. 236 (1899).

river-valleys where Pleistocene clays have been deposited; but "Upon the higher grounds . . . we meet with different soils, and in many cases poorer farms. . . . Upon the Middle Carboniferous of Kent and portions of Westmoreland counties, . . . the surface is flat and the drainage deficient; hence the soils are cold, boggy, and in many places covered with a stratum of white or gray bleached sand. . . . Upon the rolling surfaces, however, there are, as already stated, fair arable soils, though deficient in lime. . . . In Cumberland County, Nova Scotia, above the limits of the post-glacial subsidence, we meet with soils and rocks differing somewhat from those of the Middle Carboniferous just described. Here the prevailing surface beds are reddish in color, . . . here, as in New Brunswick, there is a deficiency of lime in the soil." (Chalmers, n. s. vii. 136–138M). With this extensive region "deficient in lime" extending from calcareous northern New Brunswick into Nova Scotia, it is only natural that *Thuja* should be practically absent[1] from the latter province. The failure of *Thuja* to reach Newfoundland is evidently due to the fact that the plants which reached Newfoundland from the southwest were forced to migrate on the siliceous Tertiary continental shelf which formerly connected the North American continent with Newfoundland. This point has already been sufficiently discussed elsewhere.[2]

On Prince Edward Island *Thuja occidentalis* is, as Hutchinson says, unknown from the eastern half of the island, but it is frequent and often abundant from slightly east of Badeque Bay northwestward, the half of the island where "calcareous conglomerate, the pebbles being of red shale, and containing white calcite in considerable quantity, form a feature which can be easily recognized" (Ells, Rep. for 1882–83–84, 13E).

Throughout the glaciated regions of New Brunswick and Maine, for many miles south of the region of calcareous rocks but where the soils are chiefly drift material or glacial till from the north, *Thuja occidentalis* is frequent or often abundant, and on the lower levels of

[1] By the statements of Bell, Fernow, and Hutchinson *Thuja* is said to be absent from Nova Scotia; but there is good evidence that it occurs, although very rarely and only as an unsuccessful swamp shrub, near the New Brunswick border. Thus in Lindsay's *Catalogue of the Flora of Nova Scotia* (Proc. N. S. Inst. Sci. iv. pt. 2, 209) it is recorded from Cumberland, the county immediately adjoining New Brunswick; and Professor H. G. Perry of Acadia University assures me that, although very rare and obviously not at home, *Thuja* has been observed by him in swamps of west-central Nova Scotia.

[2] Fernald, RHODORA, xiii. 161 (1911) and Am. Journ. Bot. v. 238 (1918).

New Brunswick and Maine where the noncalcareous rocks are deeply buried in Pleistocene marine clays the Cedar is often found. The very great difficulty of deciding off-hand in a drift-covered area whether a given colony of plants is in a calcareous or a non-calcareous soil has already been referred to in a quotation from Chalmers. This difficulty is made clear by the following incident. The argillaceous rocks which occupy much of the lower valley of the Penobscot are essentially non-calcareous. Yet at a few points, such as the ledges near the ferry at Veazie, there occur good developments of Arbor Vitae, accompanied by such well-recognized calcicolous herbs as *Anemone canadensis*, *A. riparia* and *Juncus brachycephalus*, species which abound in the limestone region of Aroostook County but which are exceedingly local on the lower Penobscot. The present writer called this area to the attention to one of his friends at the University of Maine, a prominent chemist and mineralogist, who, after visiting the spot and taking rock-samples, reported that the rock itself was non-calcareous but that when tested with acid the surfaces gave a marked effervescence. Further study of the region showed that at this point along the river the ledges were stained by seepage from the steep banks of an esker which follows the valley, and that the calcareous waters from the esker had here converted the non-calcareous rock into a definitely calcareous habitat.

Similarly, a small vein of calcite intruded into an otherwise non-calcareous rock will materially effect the neighboring soil, while trap dikes, which are commonly calcareous, often alter the soil-conditions of a granitic region. Again, the average botanist is likely to pass as *granite* any of the granitic series or even hornblende diorite; but the syenites and diorites furnish a slightly calcareous soil. Consequently we are too apt to infer, because a country is composed of intrusive or metamorphic rocks, that it is granite and that, therefore, plants which delight in truly calcareous soils are not to be expected. On just this point we have the clear statement of the great soil-chemist, Hilgard:

"A soil-formation overlying limestone on the slopes of a range may be wholly derived from non-calcareous formations lying at a higher elevation, or may have been leached of its original lime-content by abundant rains. The feldspars constituting rocks designated as granite, may or may not be partially or wholly of the soda-lime instead of the potash series; the mica may or may not be partially replaced by hornblende, in which cases the soil would be calcareous to the

extent of determining the character of the flora as calcifuge or calciphile, without its being at all evident in the physical character of the soil, which would still be 'granitic' or 'siliceous.' Such observations in order to be critically decisive, clearly require that the observer should be, not merely a systematic botanist, nor a mere geologist or chemist, but all these combined. There is good reason to believe that most or all of these supposed contradictions would disappear before a critical physical and chemical examination of both the soils and the rocks from which they are supposed to have been derived. Contejean himself, in placing so many of his long catalogue of plants into the doubtful groups, suggests many cases in which the above considerations may explain the apparent discrepancies.

"*What is a calcareous soil?* The definition adopted for this volume has been given in a previous chapter (chapter 19, page 367); viz, that *a soil must be considered calcareous so soon as it naturally supports a calciphile flora* — the 'lime vegetation' so often referred to above and named in detail. Upon this basis it has been seen that some (sandy) soils containing only a little over one-tenth of one per cent. of lime show all the characters and advantages of calcareous soils; while in the case of heavy clay soils, as has been shown, the lime-percentage must rise to over one-half per cent. to produce native lime growth." [1]

It is, therefore, premature to say that in the region of its almost continuous occurrence, from New Brunswick and adjacent Quebec across northern New England, northern and central New York, southern Ontario, Michigan, Wisconsin and Minnesota, *Thuja* confines itself to calcareous soils for, like many other plants in the area where they are dominant, *Thuja* may prove to be ubiquitous or somewhat indifferent to moderate differences of soil; but that its finest development in this region is in the calcareous tracts cannot be seriously questioned.

In New Brunswick and Maine *Thuja* likewise delights in the river alluvium and terraces along the principal streams, which have their upper sources in calcareous tracts for, as Hilgard clearly shows,[2] although in water draining from mixed but unmanured soils "lime is the ingredient most abundant," river waters show a marked diminution "especially of lime . . . indicating a deposition of lime carbonate

[1] Hilgard, Soils, 523, 524 (1907).
[2] Hilgard, Soils, 24 (1907).

in the river deposits or alluvial lands"; but in such valleys as that of the Saco, a river draining the granitic eastern White Mountains and consequently with alluvium deficient in lime, *Thuja* is apparently unknown.

In New Hampshire *Thuja* is abundant in the region north and northwest of the White Mountains and along the Connecticut Valley south to Hanover;[1] and it is "Common in northern and central Vermont, and as far south as Woodstock and Hartland in eastern Vermont, up to 1,000 feet altitude."[2] An examination of Hitchcock's Agricultural Map of New Hampshire[3] (the map overlapping into Maine and Vermont), shows that two-thirds of the region north and northwest of the White Mountains is indicated as having calcareous soil, partly derived from limestones, partly from calcareous slates and schists; and this calcareous area, which extends west to the granitic Green Mountains, follows south beyond Hanover, and on the Vermont side includes Woodstock and Hartland. At Hanover and at the southwestern border of Hartland and the southeastern border of Woodstock the limestone is shown as meeting regions of gneissic or granitic rock, although after skirting around these granitic masses the calcareous rocks continue southward along the Connecticut. In this calcareous area of northwestern New Hampshire and northeastern Vermont the primitive Arbor Vitae or White Cedar emulated the forests of northern Maine, northern New Brunswick and Gaspé, for in Dr. Kennedy's *Flora of Willoughby, Vermont*, we find the statement, that "Some stumps of old growth cedars, more than three feet in diameter, still remain."[4]

In Massachusetts *Thuja occidentalis* is confined to the calcareous upper Connecticut Valley and to the Stockbridge limestone region of Berkshire County.[5]

In Connecticut it is indigenous only in the limestone region of northern Litchfield county: "Canaan, on a limestone ridge and in a near-by swamp (C. K. Averill), Salisbury, rocky hillside and at another locality in a deep swamp (Mrs. C. S. Phelps)."[6]

In southern New York *Thuja occidentalis* was formerly known on

[1] Dame & Brooks, Handb. Trees of New Eng. 23 (1902).
[2] Burns & Otis, Trees of Vt. 51 (1916).
[3] C. H. Hitchcock, Geol. of N. H. i. 548 and map opposite (1874).
[4] Kennedy, Rhodora, vi. 103 (1904).
[5] See Dame & Brooks, l. c.
[6] Graves, Eames, and others, Cat. Fl. Pl. and Ferns Ct. 38 (1910).

the lower Hudson: "At Verplanck's Point . . . on . . . fine bluffs of palaeozoic limestone," [1] where it was associated with other calcicoles, *Anemone canadensis*, *Arenaria stricta*, *Arabis lyrata*, etc.; and at other stations lower down the Hudson (now presumably extinct).

In New Jersey the only authentic records are from the lower Hudson, the old records from farther west, having been doubted.[2] In other words, in Connecticut and southeastern New York and adjacent New Jersey *Thuja occidentalis* occurs only in the localities indicated so clearly on Dana's map of limestone areas of the region (including the Palisade trap range), or as Dana concisely defines it "the belts of limestone . . . which extend southward in eastern New York and from Canaan and Salisbury in Connecticut" [3] (In Connecticut *Thuja* is known only from Canaan and Salisbury!).

In Pennsylvania, according to Porter, *Thuja* is "Generally escaped from cultivation, but not definitely known in the native state;" [4] and Long likewise emphasizes that the tree "appears to be quite unknown in a native state in the wide mountain area of Pennsylvania"[5]

In Virginia *Thuja occidentalis* seems to be confined to the calcareous valleys among the mountains. The records are few, as follows: at Natural Bridge "the great *Arbor Vitae* in Cedar Creek ravine;" [6] "Plentiful along the creeks in the Valley of the Middle Fork of the Holston River, especially where the banks are rocky and cañon-like";[7] "Alleghany Co., Steele." [8] Both Cedar Creek and the Holston River are in the Great Valley or the Valley of Virginia, where the "Valley limestone . . . occupies the greater part of the floor," [9] and where, as described by W. B. Rogers, along the Holston Valley "Hills of limestone apparently arranged in rows . . . are stationed along the valley at nearly equal intervals." [10] In Alleghany County, too, although Tidestrom does not give Steele's precise locality, it is certain that *Thuja* is upon either the Silurian or Devonian calcareous rocks of which that county is composed.

[1] F. J. H. Merrill, Bull. Torr. Bot. Cl. xiii. 6 (1886).
[2] See Britton, Cat. Pl. N. J. 299 (1889), Taylor, Mem. N. Y. Bot. Gard. v. 74 (1915).
[3] Dana, Man. Geol, ed. 4, 529, 530 (1895).
[4] Porter, Fl. Penn. 3 (1903).
[5] Long, RHODORA, xv. 121 (1913).
[6] A. M. Vail, Mem. Torr. Bot. Cl. ii. 38 (1890).
[7] Small & Vail, Mem. Torr. Bot. Cl. iv. 167 (1893).
[8] Tidestrom, Elysium Marianum, ed. 2, 88 (1907).
[9] Bassler, Va. Geol. Surv. Bull. no. II-A, 36 (1909).
[10] W. B. Rogers, Geol. of Va. 140 (1884).

In West Virginia *Thuja* is known from but two localities, in the extreme Northeast: Knobly Mountain in Mineral County and near Petersburg in Grant County.[1] Knobly Mountain extends across Mineral and Grant Counties and consists, according to Darton & Taff, of Silurian limestones and calcareous sandstones,[2] while Petersburg is on the South Branch of the Potomac, which drains these and the calcareous Devonian sandstones and shales.

"This is about the rarest tree in North Carolina....It is said to occur in only a few places, as on Cripple Creek and Linville River, on limestone soil"[3]; while in Tennessee it is only "along Holston River [see above] in the mountains,"[4] the Holston in Tennessee flowing through a highly calcareous region, the rocks, as indicated by Keith,[5] being chiefly Cambrian and Silurian limestones.

In Ohio *Thuja* is known only in "Champaign, Franklin, Greene, Highland, Adams" counties;[6] Orton, on his map of the Limestone Formations of Ohio,[7] showing Champaign and Greene Counties as wholly limestone, Highland and Adams almost wholly so, and the western half of Franklin County calcareous.

In Indiana *Thuja* is known only in Lake County,[8] which is Silurian, although thinly covered at the north by the wind-blown sand-dunes beside Lake Michigan. The "Tamarack-Arbor-vitae swamp is on the eastern boundary" of the sand dunes where *Pinus Banksiana* abounds, but not on the dunes themselves. Here, however, Nieuwland informs us, "The Arbor-vitae trees are not in the best of condition,"[9] although he ascribes their poor condition to the cutting of a ditch some distance away.

So much for the southern colonies of *Thuja occidentalis*. Now turning in the opposite direction we find a strikingly similar restriction to calcareous soils of the extreme northern colonies.

In Labrador, Low states that "*Thuja occidentalis* Linn. (Cedar) hardly enters the southern limits of the peninsula. It occurs just south of the mouth of the Rupert River, at the foot of James Bay,

[1] Millspaugh, Living Flora of W. Va. 199 (1913).
[2] Darton & Taff, Piedmont Folio (no. 28), Geol. Atlas U. S. (1896).
[3] Coker & Totten, Trees of N. C. 26 (1916).
[4] Gattinger, Flora of Tenn. 32 (1901).
[5] Arthur Keith, Morristown Folio (no. 27), Gecl. Atlas U. S. (1896).
[6] Shaffner, Cat. Ohio Vasc. Pl. 136 (1914).
[7] Orton, Geol. Surv. Ohio, ser. 4, Bull. no. 4 (1906).
[8] Deam, Indiana State Bd. Forestry, Ann. Rep. xi. 110 (1912).
[9] Nieuwland, Am. Mid. Nat. ii. 165 (1912).

and does not cross that stream in the eastern course of its northern limit. It is only found about the southwestern bays of Mistassini Lake, from which it extends south-east, crossing the St. Lawrence to the westward of Seven Islands. No cedar trees were seen along the Manicuagan River from its mouth upward" (Low, n. s. viii. 33L).

In regard to the region of Seven Islands, Sir William Logan tells us that the whole north shore of the lower St. Lawrence is Laurentian, "with the exception of a narrow border of Silurian strata on the strait of Belle Isle, another at the mouth of the Mingan River, and a third near the Seven Islands."[1] The Manicuagan where "no cedar trees were seen" was explored from mouth to headwaters by Low, who writes "Rocks, of Archaean age alone, were met with along the various routes followed" (Low, l. c. 104A); but *Thuja* is found at the southern end of Lake Mistassini, for "The soil of the region about Lake Mistassini is made up of boulder-clay, derived from the disintegration of the neighbouring rocks. . . . The finer material of the soil is sandy clay, with a large percentage of finely divided and intimately mixed limestone, *especially* [italics ours] about the southern and eastern shores" (Low, l. c. 69L). It is noteworthy that in his long canoe trip — up the Saguenay to Lake St. John, thence up the Mistassini River, across to Lake Mistassini and down the Rupert to Hudson Bay — André Michaux passed *north* of the southern end of the lake and consequently did not see this northern colony of *Thuja* at the southern end of Lake Mistassini. Writing on August 21st, 1792, from "la Rivièrre ditte Mistassin," Michaux said, "Les Thuya cessent au Lac [St. Jean], dit-on, et je vis pas au long de cette riv."[2] This observation is significant for throughout its known length Mistassini River flows through acid country, but the northeastern, eastern and southeastern shores of Lake St. John are composed of anorthosite which, as already noted (p. 52), contains an average of 9 % of calcium.

Thuja is *not* found on the Rupert River which for its entire length flows over Laurentian gneiss, but it *is* found "just south of the mouth of the Rupert River," the eastern limit of the calcareous area already discussed (p. 47). Similarly it is on the lower Noddoway in the calcareous soils which reach south from James Bay (Bell, n. s. viii. 80A), the region from which *Pinus Banksiana* is absent (see p. 46).

[1] Logan, Geol. of Canada, 47 (1863).
[2] Michaux, Journal, 1787–1796, ed. Sargent, 76 (1888).

On the lower Abitibi *Thuja* occurs, the river for the lower 70 miles flowing over Devonian limestones (Wilson, xv.— for 1902–'03 — 233, 235A). On the Kwataboahegan which enters the mouth of the Moose River and which "flows over flat-lying, fossiliferous limestone for thirty-two miles," "cedar is common" (Wilson, l. c. 229–231A).

In the great Devonian and Silurian limestone region southwest and west of James Bay and Hudson Bay, *Thuja* does not stop in its northern extension at the lower Albany River as Hutchinson's map implies. It is found on most if not all of the rivers which enter James Bay from the west through this vast limestone lowland. It is on the Kapiskau, the banks of which for the lower 125 miles are composed of clay and sand "containing marine shells," but higher up of "a very soft reddish-brown argillaceous limestone" (Wilson, l. c. 224A); and it extends north to the Winisk which enters Hudson Bay in lat. 55° 20′ (Wilson, l. c.— for 1903 — 103A).

Hutchinson finds the limits of *Pinus Banksiana* "irregular" because "this species has migrated to 56° N. lat." in Labrador (which is acid Laurentian country) but "has been limited in its northward progress by the low-lying lands south and westward from James Bay" (the calcareous area). Why not reverse the argument and say that the limits of *Thuja occidentalis* are "irregular," since on the low-lying country southwest of Hudson Bay it has extended beyond 55° N. latitude, while it "has been limited in its northward progress" in Labrador by the Laurentian upland?

On the headwaters of the Severn River, entering Hudson Bay northwest of the Winisk, *Thuja* reaches its northern limit in that direction, though it is "a rare tree," nearly the whole country being Archaean, "but it occurs on the east end of Slate lake, on Sesikinaga lake, on Cedar (Kishikas) lake, and also on Greenshields lake. On the shores of the last a few rusty looking trees are growing, and this is their northern limit" (Camsell, xvi. 151A). The whole region is granite and gneiss, except for a few limited areas: "The valley of Slate lake, which has been formed by the erosion of the soft calc schists" (Camsell, l. c. 148A); "Two narrow tongues, however, of basic rocks" which "intervene before reaching Gull lake. One of these occurs on the Sesikinaga river" (Camsell, l. c. 147A); "basic inclusions . . . on the lake at the head of Cedar river; on the lower end of Cedar (Kishikas) lake" (Camsell, l. c. 148A); while "The highest hill in the whole area is situated about three miles west of Greenshields

lake. It rises 300 feet above the level of the water and is composed seemingly entirely of boulders and drift material" (Camsell, l. c. 146A).

Hutchinson quotes Bell's old statement that "there is a remarkable outlier of white cedar brushwood around Cedar Lake on the upper part of the Saskatchewan River at a distance of 190 miles to the northwest of the nearest point of the main area covered by this species." It is, therefore, significant to find Dowling stating that the Devonian coralline limestones of James Bay "are similar to rocks of Silurian age on Cedar lake in the Saskatchewan district" (Dowling, n. s. xiv. 36F). And is it not significant, also, that Hutchinson, writing of a vast Archaean country should state that "it is notable that throughout great areas, for instance the Temagami region, *Thuja* is unknown?" At this point in his discussion he was near the answer to his problem and had he pursued the question with that "notable" fact as a basis he would quickly have discovered the truth: that THUJA OCCIDENTALIS *is almost as pronouncedly calcicolous as* PINUS BANKSIANA *is calciphobous.*

The impression seems to be very general that *Thuja* prefers swamps, yet it is certainly noteworthy that in really wet swamps it is usually only a shrub or small tree, there rarely developing trunks 1 foot in diameter. In the area of its best development, the calcareous region of northern Maine, northwestern New Brunswick, and the Gaspé Peninsula, the splendid trees with trunks often 3 feet in diameter and sometimes twice that size are always on the well drained river-terraces or alluvial banks or on rocky slopes. In New Brunswick Ganong likewise notes that *Thuja* "shows a marked dualism of habitat, occurring most characteristically in low wet places ('Cedar swamps') but also capable, (at least individual trees are) of existence upon upland where conditions approach the xerophytic."[1] Similarly Professor L. W. Bailey described the Tobique as passing "near the base of high and precipitous cliffs of ferruginous rock, overhung with cedar";[2] in Connecticut two of the three stations are on limestone ledges; on the lower Hudson it was "on . . . fine bluffs of paleozoic limestone," and nearly at the southern limit of the species, along the Holston River, at altitudes mostly under 1,000 feet, "especially where the banks are rocky and cañon-like . . . . Measurements of the largest

[1] Ganong, Bull. Nat. Hist. Soc. N. B. xxi. 55 (1902).
[2] L. W. Bailey, Can. Nat. ser. 2, i. 82 (1864).

trees were taken which showed trunks at each locality of about fifteen feet in circumference."[1]

These facts indicate conclusively enough that, although in swamps *Thuja* forms impenetrable tangles of low, usually interlocking, small trees, it is on the better-drained or even xerophytic rock-habitats that it develops its full stature. Consequently if, as Hutchinson says, water is the "limiting factor" which prevents *Pinus Banksiana* from spreading into the limestone region southwest of James Bay, it certainly cannot be argued that *lack of water* is the factor which keeps *Thuja* from pushing north on the acid Archaean country; but, even if it be urged that *Thuja* most commonly occurs in swamps, it must be evident that there are plenty of swamps on the Labrador Peninsula, for Low tells us that water covers "at a moderate estimate, at least one fourth of the total area" of the peninsula (Low, n. s. viii. 23L).

Hutchinson (p. 488) says, further, that "The presence of 'outliers' . . . indicates that the general area of its distribution does not extend to its ecological limit, in many instances at least. The northern area of its distribution is roughly outlined by a semicircle, a fact which contributes evidence that *Thuja* has migrated radiately from a limited area . . . it does not migrate rapidly . . . this form has lagged behind." When, therefore, following Hutchinson's suggestion, we draw the circle connecting the "outliers" (in western North Carolina, western Prince Edward Island, western Anticosti, and Cedar Lake on the Saskatchewan) it is impressive to find that the center of the circle falls in the great acid Archaean area northeast of Lake Superior, the Temagami region; for Hutchinson particularly informs us that "it is notable that throughout great areas, for instance the Temagami region, *Thuja* is unknown." And since the Temagami region was not accessible to forests until after the vanishing of the Pleistocene ice, by Hutchinson's interpretation that the tree has "migrated radiately" we are forced to the dramatic picture of the infant *Thuja occidentalis* created in very modern times in the center of the Temagami region and finding nothing to live on, migrating as rapidly as its "lagging" tendency would allow to the calcareous regions northwest, north, east, and south!

Wherever the "Cedar swamp" is open and full of glades or swales it supports a characteristic vegetation quite unlike that of the acid

[1] Small & Vail, Mem. Torr. Bot. Cl. iv. 167 (1893).

bog, the following species being found in many such swamps of northern Maine, New Brunswick or Gaspé: *Selaginella selaginoides, Equisetum palustre* and *E. scirpoides, Triglochin palustris* and *T. maritima, Scirpus pauciflorus* and *S. hudsonianus, Eriophorum viridi-carinatum, Carex gynocrates, C. chordorhiza* and *C. vaginata, Juncus stygius, Orchis rotundifolia, Calypso bulbosa, Microstylis monophyllos, Cypripedium hirsutum* and *C. parviflorum, Betula pumila, Caltha palustris, Geum rivale, Rhamnus alnifolia, Angelica atropurpurea, Veronica americana, Valeriana uliginosa, Galium palustre,* and *Lonicera oblongifolia.* This long list of species is here entered because in Europe nearly all of them or their immediate European allies occur in the "low-moors," and Warming, the father of modern ecology, correctly states that "The water coming from low-moor is *rich in calcium and potassium.*"[1] *The Canadian "Cedar swamp" is, then, a phase of Warming's calcareous "low-moor"*; and every farmer in northern Maine and New Brunswick knows perfectly well that by clearing a "Cedar swamp" he will get a valuable addition to his tillable acreage, but, wherever *Pinus Banksiana* grows the farmer knows it is useless to attempt cultivation. In fact, even the most ignorant "habitant" will argue that whenever that pine ("Cyprès," as he calls it) takes possession it makes the region sterile, and so powerful is its sterilizing influence that it is considered positively dangerous for a pregnant woman even to walk near a Banksian pine!

The law that some plants are oxylophytes, some calcicoles, is "as old as the hills" and it is just as true today as it was when Linney wrote of Kentucky: "Altitudes had little, here, to do with the distribution of the trees; only two natural conditions seem to have modified their disposition: one of minor importance — the quantity of moisture; and the other of much consequence — the character of the soil";[2] or when that great geologist, J. W. Dawson, wrote:

"Until the botanical geographer pursues his studies of distribution with a geological map in his hand, and a knowledge of the habitudes of plants in reference to soils, his labours will be to a great extent fruitless. A little more lime or a little less alkali in the soil renders vast regions uninhabitable by certain species of plants. For many of the plants of our Laurentide hills to extend themselves over the calcareous

[1] Warming, Oecology of Plants, transl. Groom & Balfour, 197 (1909).
[2] Linney, Bot. of Madison, Lincoln, Garrard, Washington and Marion Counties, Ky. 8 (1882).

plains south of them, under any imaginable conditions of climate, is quite as far beyond the range of possibility as to extend across the wide ocean."[1]

The fact that many plants are calcicolous, many calcifuge, is clearly recognized by the European ecologists, Tansley in his wonderfully lucid little book, *Types of British Vegetation*, saying with perfect positiveness: "Soils containing a comparatively large proportion of lime are always marked by the presence and usually by the abundance of certain species of plants — the so-called 'calcicole' species. . . . Contrasting with the 'calcicole' species there are others, called 'calcifuge' which appear to be really intolerant of much lime in the soil."[2]

Again, Praeger in his monumental *Irish Topographical Botany* says without quibble: "The presence or absence of lime is the most important particular in which petrology affects the distribution of plants; and in Ireland the bold grouping of the calcareous and non-calcareous rocks helps to emphasize this feature of phytogeology. . . . A knob of Old Red Sandstone . . . breaking through the limestone crust of the Central Plain, immediately produces *Galium saxatile*, *Vaccinium Myrtillus*, *Rumex Acetosella*, *Deschampsia flexuosa*, and other characteristic calcifuge species. . . . The converse case — the absence of calcicole species in counties poor in or devoid of limestone — is more strongly marked. . . . A . . . conspicuous line of demarkation — indeed one of the most remarkable phytogeological boundaries in Ireland — is seen where the Central Plain limestones lie up against the ancient metamorphic highlands of Connaught. . . . Here, as we pass off the limestone, *Habenaria intacta*, *Gentiana verna*, *Sesleria*, and other interesting plants which have been our companions over many miles, give way abruptly."[3]

Why is this almost axiomatic law blindly ignored or only grudgingly admitted by so many American physiographic ecologists and phytogeographers? That it is fundamental is beyond dispute, and by the English, Irish, and many other European investigators is clearly recognized as an essential factor in phytogeography; and as someone has said, "If the English and Irish agree on it, it must be so." Until American physiographic ecologists and phytogeographers recognize and use this law as a constant guide their labors, as Dawson prophetically said, "will be to a great extent fruitless."

[1] J. W. Dawson, Can. Nat. and Geol. vii. 342 (1862).
[2] Tansley, Types of Brit. Veg. 144 (1911).
[3] Praeger, Irish Topogr. Bot.: Proc. Royal Irish Acad. vii. p. xxvii (1901).

Though, as just said, the law itself is "as old as the hills," the recognition of it, naturally, is much more recent. Nevertheless it was clearly comprehended by the ancient Greeks. Here are the words of Theophrastus, written about 300 B. C.: "Yet it is not strange that there should be some mountains which do not thus bear all things, but have a more special kind of vegetation to a great extent if not entirely: for instance the range of Ida in Crete, for there Cupressus grows; or the hills of Cilicia and Syria, on which Cedrus grows; or certain parts of Syria where the terebinth grows. For it is the differences of soil which give a special character to the vegetation."[1]

Cowles, who has found it necessary elsewhere to explain that he is one of "those of broader viewpoint," says that "The world of morphologists, physiologists and ecologists has borne with" the sinning taxonomist "patiently and long . . . a little more and the sinning taxonomist will be 'cast out into the outer darkness where there shall be wailing and gnashing of teeth'," [2] but he says nothing about our toleration of the sinning ecologist.[3] Two of the great truths of science taught by the ancient Greeks, and just as true now as prior to the Christian era, were (1) that "it is the differences of soil which give a special character to the vegetation"; and (2) that the earth is round. In these days anyone who seriously argues that the earth is flat is treated as a pitiable eccentric or is kept in confinement.

GRAY HERBARIUM.

[1] Theophrastus, Hist. Plant. lib. iii. cap. 3 (circ. 300 B. C.).

[2] Cowles, Am. Nat. xlii. 270, 271 (1908).

[3] Everyone, however, will agree with Cowles when in the same paragraph he says: "Species-making by taxonomic tyros must be abandoned"; but it is certainly diverting, that on the preceding page Cowles tried his hand at a most difficult genus and published two brand-new combinations, "*Crataegus mollis ellwangeriana*" and "*C. mollis champlainensis*," although in doing so he violated three of the articles of the International Code, which in a preceding paragraph he seems to defend: publishing without an adequate bibliographic reference to the name-bringing synonym; making trinomials, without indicating the category (whether subspecies, variety, or form); and decapitalizing a personal name, *Ellwangeriana*. Naturally, if this represents an ecologist's conception of taxonomic work it is not surprising that Cowles should condemn the "sinning" taxonomist.